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1. Introduction

This report aims to explore patient data, which is stratified based on dementia status. This includes individuals diagnosed with dementia, those without, and those whose status shifted to dementia over time. The primary focus of the investigation is to track the impact and interaction of dementia on eTIV and nWBV among these distinct groups and across multiple visits.

There are 2 research questions that will be discussed in the following analysis:

1. What is the impact and interaction of dementia on eTIV, among different groups and visit times?
2. What is the impact and interaction of dementia on nWBV, among different groups and visit times?

Prior to the data analysis, a cleaning process was done to eliminate any missing and incomplete data. Also, a mixed-effects ANOVA was employed to assess the effects of time and group on eTIV and nWBV. The assumptions test provided further insights into the group differences, and a power analysis ensured the statistical analysis of the findings.

2. Exploratory Data Analysis
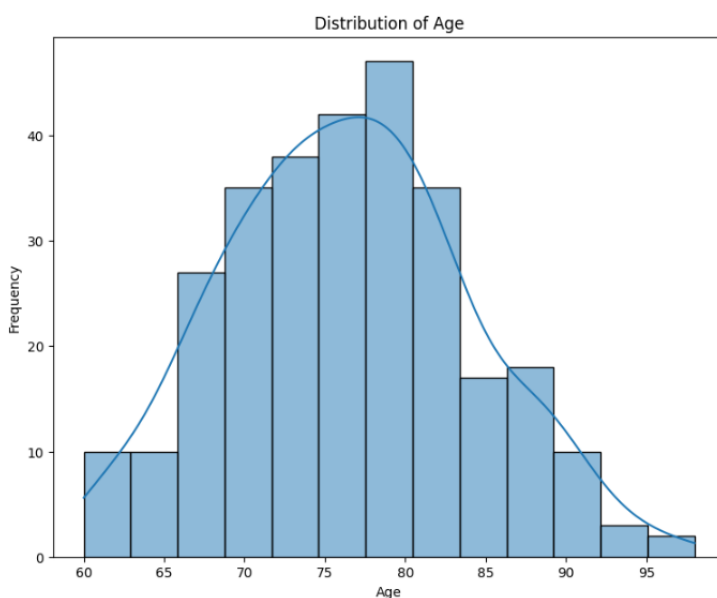
The data appears to be approximately normally distributed, with the most common age being around 80. The age range extends from about 60 to 95, and the distribution is slightly right-skewed, indicating there are more individuals older than 80 than younger. The peak frequency exceeds 40 occurrences at the age of 80. And the age of 80 is the most typical.

3. Mixed-effect ANOVA

Research question 1: What is the impact and interaction of dementia on eTIV, among different groups and visit times?

The null hypothesis is that there is no significant difference in the impact and interaction of dementia on eTIV, among different groups and visit times.
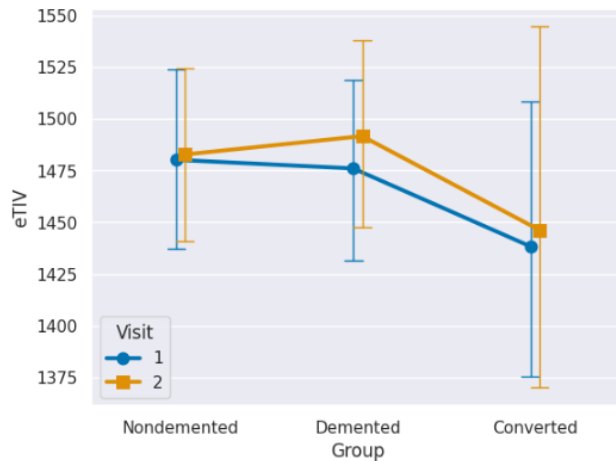
	Source	SS	DF1	DF2	MS	F	p-unc	np2	eps
0	Group	37424.7084	2	141	18712.3542	0.297278	0.743302	0.004199	NaN
1	Visit	5573.92014	1	141	5573.92014	9.2249	0.002845	0.061407	1
2	Interaction	1004.78316	2	141	502.391582	0.831464	0.437535	0.011656	NaN

The mixed-effects ANOVA analysis reveals several key findings regarding the estimated Total Intracranial Volume (eTIV) across different groups and visit times. Firstly, the analysis indicates no significant main effect of the Group variable on eTIV, as evidenced by an F-value below the p-value ($p > 0.05$). This suggests that the mean eTIV is not significantly different across the examined groups.

Additionally, the interaction effect between Group and Visit was found to be non-significant. This lack of significant interaction implies that the pattern of eTIV change across different visits does not differ among the groups; in other words, the temporal progression of eTIV does not vary based on group membership.

However, the analysis did identify a significant main effect of Visit on eTIV, with the corresponding p-value falling below the 0.05. This result highlights a statistically significant change in eTIV over time. But the associated effect size is small, indicating that while the change is statistically significant, its may not be of substantial practical importance.
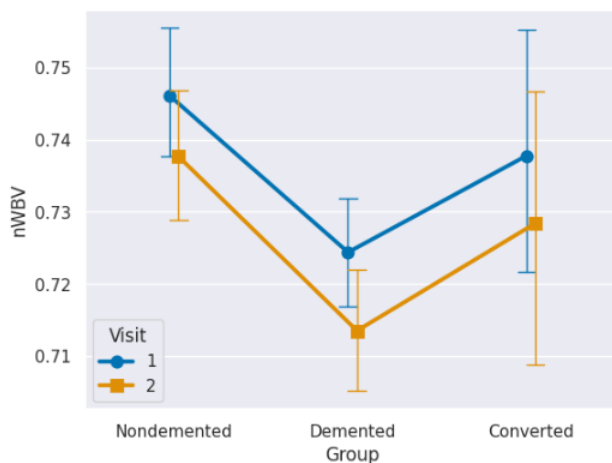
The validity of the mixed-effects ANOVA results is supported by the satisfaction of its assumptions. The assumption of sphericity, assessed via Mauchly's test, is upheld ($p > 0.05$), indicating equal variances of the differences between all combinations of related group levels. The assumption of normality, verified by the Shapiro-Wilk test, is also met as the data distributions for all factor

combinations did not significantly deviate from normality (p > 0.05). Lastly, the homogeneity of variance, as tested by Levene's test, is confirmed (p > 0.05), ensuring that the variance across the groups is consistent.

In summary, the mixed-effects ANOVA suggests that while visit time is a determinant in the variability of eTIV, the group factor and the group-visit interaction do not significantly contribute to such variability.

Research question 2: **What is the impact and interaction of dementia on nWBV, among different groups and visit times?**

The null hypothesis is that there is no significant difference in the impact and interaction of dementia on nWBV, among different groups and visit times.

	Source	SS	DF1	DF2	MS	F	p-unc	np2	eps
0	Group	0.03364	2	141	0.01682	6.712381	1.64E-03	0.086934	NaN
1	Visit	0.006508	1	141	0.006508	94.25123	2.23E-17	0.400641	1
2	Interaction	0.000212	2	141	0.000106	1.533508	2.19E-01	0.021289	NaN

The mixed-effects ANOVA results indicate significant main effects of Group and Visit on the normalized Whole Brain Volume (nWBV). This suggests that nWBV varies among the different groups as well as across different visit times. Specifically, the main effect of Group, while statistically significant, is associated with a small effect size, indicating that differences between groups, though reliable, are not large in magnitude. Conversely, the main effect of Visit exhibits a big effect size, highlighting a more pronounced change in nWBV over time.

Despite these main effects, the analysis does not demonstrate a significant interaction effect between Group and Visit. This indicates that the patterns of change in nWBV across visits do not differ significantly among the groups. In other words, while the groups may differ in their nWBV and nWBV changes over time, the rate of change is consistent across groups.

In regards to the assumptions required for the mixed-effects ANOVA:

Sphericity: The Mauchly's test result, with a p-value greater than 0.05, suggests that the assumption of sphericity is met.

Normality: The Shapiro-Wilk test indicates normal distribution of nWBV data across all combinations of factors ($p > 0.05$), meeting the normality assumption.

Homogeneity of Variance: Levene's test results in p-values greater than 0.05 for homogeneity of variances within groups, satisfying the homogeneity assumption.

In conclusion, the mixed-effects ANOVA analysis confirms that group membership and time of visit are both influential factors for nWBV. However, the lack of a significant interaction effect suggests that these factors operate independently of each other regarding their influence on nWBV.

4. Power Analysis
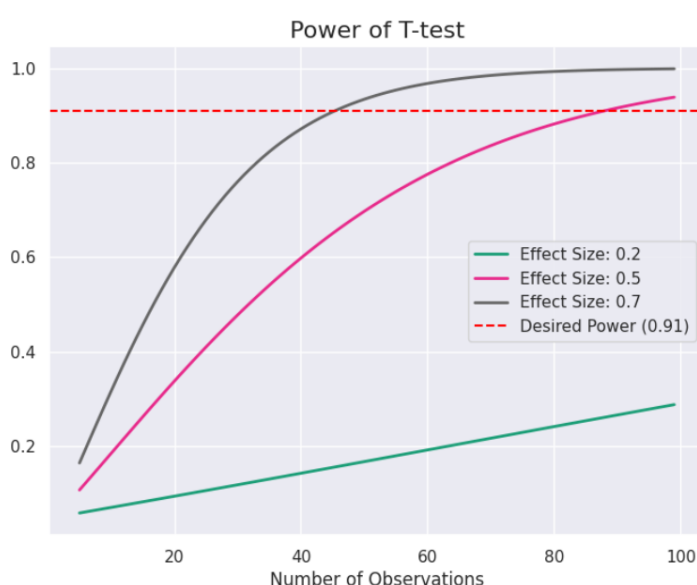
The power analysis graph illustrates that statistical power, or the probability of correctly detecting an effect, escalates with the increase in both the sample size and the effect size. For an effect size of 0.7, the graph indicates that approximately 46 participants would be required to achieve a 91% power.

5. Conclusion

To conclude, this report explored the effects of dementia on eTIV and nWBV across patient groups and over time. The data's age distribution was approximately normal with more older individuals. The mixed-effects ANOVA revealed that time significantly influenced eTIV, but no interaction with dementia status was observed. For nWBV, both group and visit time were influential, yet their interaction wasn't significant, suggesting a uniform change rate across groups. Assumptions for the ANOVA were met, validating the findings. Power analysis emphasized the importance of sample and effect sizes for statistical power. The results enhance our understanding of dementia's progression and its impact on brain volumes.